Gas Conditioning System, Fresno/Clovis, CA
Photo courtesy SCS Engineers.

Pipeline-Quality Landfill Gas: Renewed Interest for Your Landfill?

This article examines renewable natural gas revenue sources and provides guidelines for how to evaluate the prospects for this type of renewable energy project at a landfill.

The technology to convert landfill gas (LFG) into renewable natural gas (RNG) has been available for decades, but interest has intensified in recent years due to a variety of factors that increase the economic value of RNG projects. Although RNG may offer many benefits, these projects are not for every landfill. RNG projects carry significant investment risks due to high development costs, market volatility, and potentially burdensome project logistics.

What Is RNG?

RNG—renewable natural gas—is a renewable, non-fossil fuel of nearly pure methane gas that, following treatment, is compatible with pipeline-quality natural gas. The focus of this article is RNG produced by treating LFG, the gas produced by the decomposition of organic waste in landfills, to create a gas that can be injected into the natural gas pipeline network. RNG is not a new concept; it has existed as a commercially viable, though relatively uncommon, use of LFG since the 1980s and is sometimes known as high-Btu and pipeline injection. While not new, this beneficial use of LFG is enjoying increased popularity primarily due to the promise of greater revenue. RNG project feasibility is now within reach of more landfills. However, significant limitations and risks remain.

While this article deals with LFG-produced gas for injection into the pipeline or local distribution system, it should be noted that RNG can, and is, produced from other sources such as anaerobic digestion from agricultural waste, dairy farms, and wastewater treatment. RNG can also be used in place of natural gas as transportation fuel for compressed gas-powered vehicles; an approach applied to some solid waste collection vehicles and municipal bus fleets.

Commercially Valuable Energy Source and Potent Greenhouse Gas

Due to LFG's high energy content, its beneficial use has helped both landfill owners and the environment. LFG consists of approximately 50% methane, which means it is both a potential energy source at about 500 Btu/scf and a greenhouse gas roughly 25 times more potent than carbon dioxide. By recovering the energy value of LFG, energy projects can offset natural gas or fossil-fuel-generated electricity with a non-fossil fuel as well as a reduction in methane emissions. The treatment technologies briefly described below convert LFG into a product essentially indistinguishable from natural gas.

Turning LFG into pipeline-quality natural gas requires two main steps:

1. The removal of moisture and trace components by refrigeration, dehydration, filtration, adsorption or other processes.
2. The removal of carbon dioxide through several process options: Pressure Swing Adsorption (PSA), Selexol (or other solvent-based systems), membrane separation, or a combination.

Note that an optional third step, nitrogen removal, may be necessary using a molecular sieve with a PSA system. Although nitrogen removal is a potentially expensive step, LFG wellfield operations can be simplified by more tolerant inert gas constraints at the inlet to the treatment plant. Historically, very low nitrogen and oxygen limits for the collected LFG required lower vacuum application, denser spacing of collection components, and extra measures to reduce air intrusion (e.g., membrane boots and fused high-density polyethylene [HDPE] wellheads). These system adjustments sometimes were incompatible with landfills also dealing with odors or migration issues requiring higher system vacuums. With the increased revenue potential for RNG, the additional capital and operational expense for nitrogen removal may be determined to be a reasonable step as it causes less disruption to wellfield operations and may increase collected gas flow rates.

There are a couple of other site-specific LFG parameters that may need to be addressed with additional treatment steps: hydrogen sulfide and siloxanes. The level of these constituents in the gas may require pretreatment before the gas is acceptable to the host utility. Hydrogen sulfide is present in LFG, but its concentration varies greatly from landfill to landfill (and by age of waste). There are specifications available for the permissible, pipeline-utility sulfur content. The LFG stream may also contain high levels of siloxanes, a collective term for a family of compounds often present in LFG. Like hydrogen sulfide, siloxane content can vary considerably between landfills, and natural gas utility specifications for RNG can also vary; therefore, the removal of siloxanes should be evaluated on a case-by-case basis. Capital and operating expenses associated with the removal of hydrogen sulfide and siloxanes will affect project economics.

What's the Attraction?

According to the U.S. Environmental Protection Agency's (EPA) Landfill Methane Outreach Program database, there are 62 operational LFG-to-RNG facilities (55 pipeline injection and 7 local use) at the time of this writing. If this beneficial use for LFG has existed for a while, why the new appeal? A look at the revenue associated with RNG projects helps explain the upswing in interest.

RNG revenue comes from two main sources: value from the energy content, and value derived from environmental attributes, which stem from both federal and state renewable fuel credit programs. Currently, governmental credits are responsible for the lion's share of the economic benefit of these projects.

Energy Value

Energy value, while critical to the price, is not the key reason for the intensified interest. LFG's energy content is always of value to an energy purchaser. The value for energy is captured in the LFG sales price, usually in the form of US$/MMBtu, and is tied to energy prices, which means this

portion of revenue is subject to commodity price fluctuations. Historically, mitigating this risk for landfill owners (or project developers) has involved medium to long-term contracts at a mutually agreed sale price or base price with a floor and ceiling to moderate commodity prices swings.

For RNG projects, fixed-price contracts, often involving a gas utility tariff, are part of the project structure. Being tied to the natural gas commodity price, the energy value of LFG has generally fallen in recent years (see Figure 1), mainly as a result of increased supply of natural gas. In 2019, the Natural Gas Henry Hub price ranged from US$3.11/MMBtu in winter to a summer low of US$2.22/MMBtu. The lower cost, larger supply, and emissions advantages of natural gas relative to most other fossil-sources of fuel encourage the use of natural gas and can indirectly increase the attractiveness of RNG projects.

Federal Renewable Fuel Standard

A federal policy implementation, the Renewable Fuel Standard (RFS), has enhanced the attractiveness and encouraged the development of RNG projects, including those at landfills. Projects that qualify for RFS can generate renewable identification numbers (RINs), which are a credit commodity that trades in units of US$/gal. The value of RINs, which are offset credits for displacing fossil-based transportation fuel, are a key driver in fueling the RNG market. This is the same program that drives the ethanol market. RINs are creating value for RNG providers because they allow fuel producers to offset the fossil production with a non-fossil source.

Figure 2 provides a flowchart example of RIN generation and retirement, and Figure 3 illustrates the recent interest in RINs. RINs are tradeable commodities, and therefore, brokers are a key intermediary for a successful project. Qualified brokers provide RIN verification and tracking, access to customers for transportation fuel, and can function as the landfill's buyer of the environmental attribute. Recent RIN values have ranged from US$2.16/gal (US$19.30 /MMBtu) in January 2019 to an August 2019 trading value of US$0.64/gal (US$5.75/MMBtu). While the trading value of RINs has declined over this period, the value remains significantly higher than the energy value.

A significant risk associated with RFS is due to its nature as a regulatory measure: as political support for such environmental subsidies or rule-driven mechanisms change over time, RFS could vanish or change in ways that can be detrimental to project revenue. The RFS allocations are set o expire in 2022 and possibly no new allocations will be allotted. This uncertainty will negatively impact the willingness to engage in long term contracts.

State-Level Programs

Some states have programs that can also create value for RNG projects. California's program is known as the Low Carbon Fuel Standard (LCFS) and requires a physical pipeline pathway to theoretically route gas into its market. LCFS credits are priced in units of US$/metric ton and in some cases can exceed the value of federal RINs.

Is Your Landfill a Candidate for LFG-to-RNG?

RNG presents considerable advantages to landfill owners: economics that are currently attractive for a beneficial-use energy project and minimal on-site air emissions (since the product gas is combusted elsewhere). RNG can be considered an aspect of environmentally sustainable waste practices.

As an RNG producer, a landfill is a promising resource: a resource with steady gas production, long-lived potential, economies of scale, and often coupled with a potential user (i.e., vehicle fleets involved with waste collection and transport). However, not all landfills are suitable candidates. To

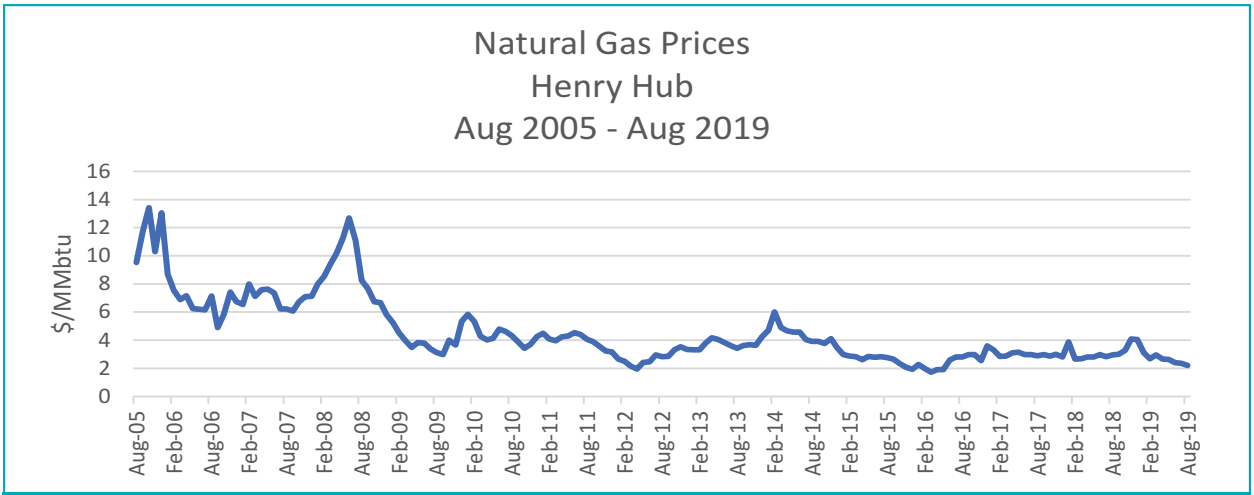

Figure 1. Declining natural gas prices.
Source: U.S. Energy Information Administration (www.eia.gov).

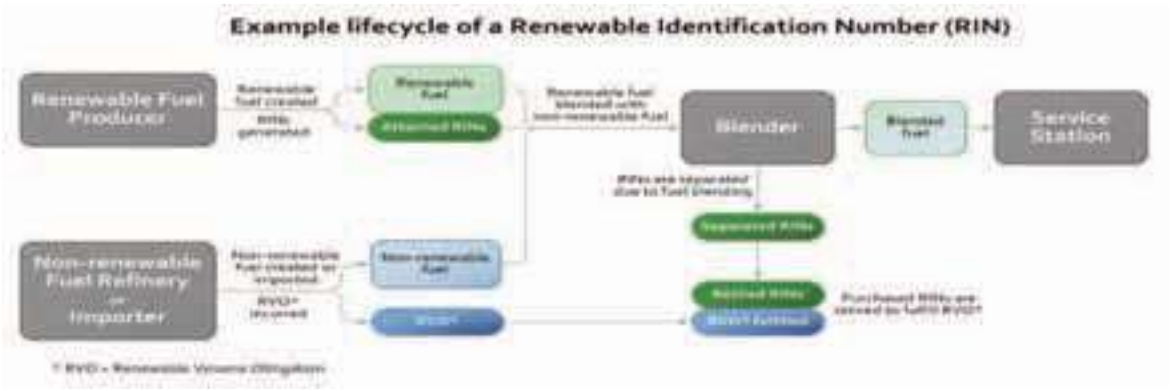

Figure 2. . Example lifecycle of a renewable identification number (RIN).
Source: U.S. Environmental Protection Agency (www.epa.gov).

determine if your landfill is a promising RNG candidate, carefully consider the following.

The Customer

The first consideration should be the customer. Questions to consider include: Is there a utility willing to take the gas at mutually agreeable terms? How much will an interconnection with the utility's pipeline cost? What is the distance from the landfill to such an injection point? What is the cost to build a connecting pipeline? Are there difficulties posed by geography or land ownership? If seeking to fuel a collection fleet: Is infrastructure for vehicle fleet fuel sufficiently available? Are the natural gas fueling stations advantageously located for an RNG project?

Landfill Gas Production

Another consideration is LFG production. Is the amount of LFG currently recovered, and the amount projected to be recovered over coming years, sufficient to generate revenues to offset costs associated with an RNG project? Is the LFG-producing landfill facility now closed, or is it presently operating and projected to continue receiving waste for an extended period?

Prediction always poses an uncertainty risk. One key to reducing this risk is the accurate prediction of how much LFG will be recovered. The landfill owner should ask, "How are future LFG flows projected?" The use of EPA's LandGEM model, designed for regulatory purposes, could over-predict the amount of gas available for a project, leading to an overly optimistic basis for capital spending. A better approach is a knowledgeable assessment of the landfill's LFG production through historic flow data and LFG recovery modeling, which includes gas collection and control system buildout, waste fill patterns,

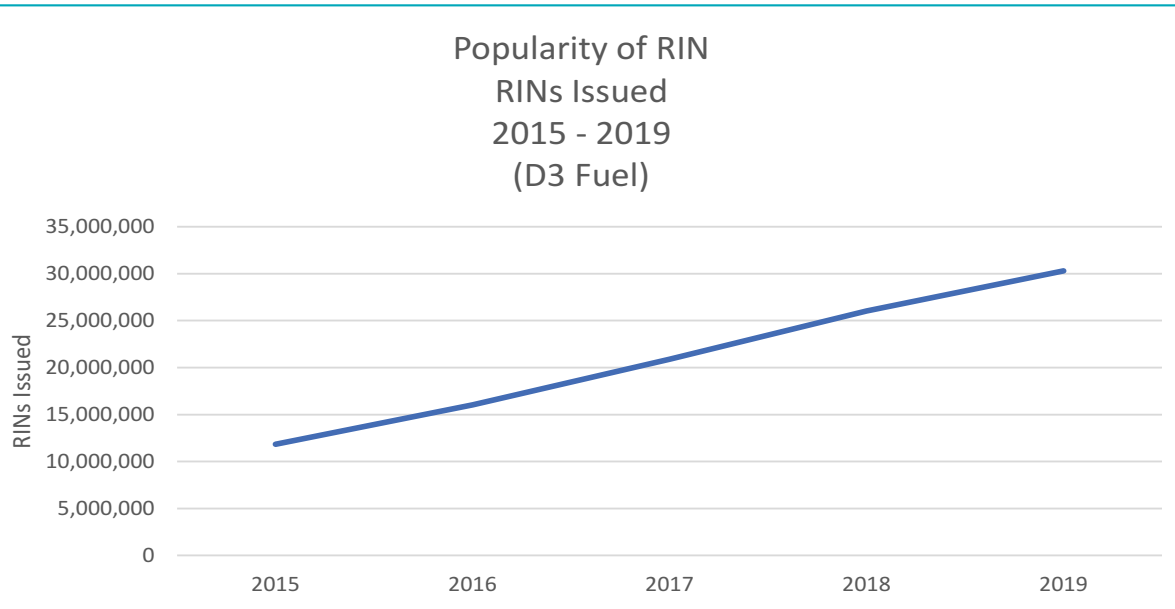

Figure 3. RINs Popularity.
Source: U.S. Energy Information Administration (www.eia.gov).

Gas well and dumping. *Photo courtesy SCS Engineers.*

and LFG well-field coverage.

A solid understanding of gas extraction system performance is required to quantify the revenue potential for the project. Are methane levels in the desired, 45–60% range? Are the current LFG wells located in gas-productive areas? Are there issues with high oxygen or nitrogen levels in the LFG? Are there leachate pockets inhibiting a stable consistent supply of LFG? Are hydrogen sulfide and siloxanes concentrations high in the LFG?

Project Rights and Development

An important question to consider is whether you own the rights to the LFG produced. Unless an RNG project will be self-owned and operated, is a qualified developer available on mutually agreeable terms? If the landfill is a municipal-owned site, are there administrative hurdles to such a project? To a large extent, successful RNG projects require different skills from those needed for successful landfill operation. Engage a qualified engineering firm to assist with technology infrastructure choices and economic evaluation. Are there experienced project developers and RIN brokers identified?

Conclusion

RNG projects can be a promising revenue source and an attractive beneficial-use option for landfill owners; however, some substantial risks exist in bringing a project to fruition and sustaining its operation. These are large, high-tech engineering projects built on future projections of revenue. In assessing the economic viability of an RNG project, be keenly aware of future uncertainty in the RIN market. RIN values trended down in 2019 combined with uncertainty for a renewal of the RFS. Such trends can discourage developers from assuming financial risks for a project. To better ensure a successful RNG project at your landfill, be sure to do your homework, engage industry professionals, and move deliberately. **em**

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